MI

Miniature Infrared Sensor



Operating Instructions

Raytek®

Noncontact Temperature Measurement

Rev. E 10/2004
54301



Declaration of Conformity for the European Community

This instrument conforms to:

EMC: IEC/EN 61326-1

Safety: EN 61010-1:1993 / A2:1995

WARRANTY

The manufacturer warrants this instrument to be free from defects in material and workmanship under normal use and service for the period of two years from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, batteries, or any product that has been subject to misuse, neglect, accident, or abnormal conditions of operation.

In the event of failure of a product covered by this warranty, the manufacturer will repair the instrument when it is returned by the purchaser, freight prepaid, to an authorized Service Facility within the applicable warranty period, provided manufacturer's examination discloses to its satisfaction that the product was defective. The manufacturer may, at its option, replace the product in lieu of repair. With regard to any covered product returned within the applicable warranty period, repairs or replacement will be made without charge and with return freight paid by the manufacturer, unless the failure was caused by misuse, neglect, accident, or abnormal conditions of operation or storage, in which case repairs will be billed at a reasonable cost. In such a case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. THE MANUFACTURER SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

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1 Safety Instructions

This document contains important information, which should be kept at all times with the instrument during its operational life. Other users of this instrument should be given these instructions with the instrument. Eventual updates to this information must be added to the original document. The instrument should only be operated by trained personnel in accordance with these instructions and local safety regulations.

Acceptable Operation

This instrument is intended only for the measurement of temperature. The instrument is appropriate for continuous use. The instrument operates reliably in demanding conditions, such as in high environmental temperatures, as long as the documented technical specifications for all instrument components are adhered to. Compliance with the operating instructions is necessary to ensure the expected results.

Unacceptable Operation

The instrument should not be used for medical diagnosis.

Replacement Parts and Accessories

Use only original parts and accessories approved by the manufacturer. The use of other products can compromise the operational safety and functionality of the instrument.

Instrument Disposal

Disposal of old instruments should be handled according to professional and environmental regulations as electronic waste.

Operating Instructions

The following symbols are used to highlight essential safety information in the operation instructions:



Helpful information regarding the optimal use of the instrument.



Warnings concerning operation to avoid instrument damage.



Warnings concerning operation to avoid personal injury.

Pay particular attention to the following safety instructions.



Use in 110 / 230 VAC electrical systems can result in electrical hazards and personal injury if not properly protected. All instrument parts supplied by electricity must be covered to prevent physical contact and other hazards at all times.

2 Description

The miniature infrared sensors MI are noncontact infrared temperature measurement systems. They accurately and repeat ably measure the amount of energy emitted from an object and convert that energy into a temperature signal.

The following outputs are available:

- J-Thermocouple
- K-Thermocouple
- 0 - 5 Volt
- 0 - 20 mA or 4 - 20 mA
- 10 mV / °C head ambient temperature signal
- RS232 interface
- optional: RS485 interface

The sensing head is protected by a rugged IEC 529 (IP 65, NEMA-4) stainless steel housing, and is connected to the electronic box with a 1 m (3 ft) cable. Longer cables must be ordered as an option. The electronic box is separated from the sensing head. This allows the sensing head to be used in hot environments up to 180°C (356°F) without cooling. The electronic box can only be used in ambient temperatures up to 65°C (150°F).

3 Technical Data

3.1 Measurement Specifications

Temperature Range

LT	-40 to 600°C (-40 to 1112°F)
	for J-Thermocouple: -25 to 600°C (-13 to 1112°F)

Spectral Response

LT	8 to 14 µm

Response Time

All models	150 ms (95% response)

Accuracy

LT	± 1% or ± 1°C (± 2°F) whichever is greater
LT	± 2°C (± 4°F) for target temp. < – 20°C (4°F)
TC outputs	± 1% or ± 2.5°C (± 5°F) whichever is greater

At ambient temperature 23°C ±5°C (73°F ±9°F)

Repeatability

All models	± 0.5% or ± 0.5°C (± 1°F) whichever is greater

Temperature Resolution

LT	± 0.1 K (± 0.2°F)*
	± 0.25 K (± 0.5°F)**

At ambient temperature 23°C ± 5°C (73°F ± 9°F)

* For a zoomed temperature span of 300°C (600°F)

** For the full temperature range of the unit

Temperature Coefficient

MIC	± 0.05 K per K or ± 0,05% / K whichever is greater, at ambient: 23 to 125°C (73 to 185°F)
MIH	± 0.05 K per K or ± 0,05% / K whichever is greater, at ambient: 23 to 180°C (73 to 356°F)
MIC, MIH	± 0.1 K per K or ± 0.1% per K whichever is greater, at ambient: 0 to 23°C (32 to 73°F)
MID	± 0.15 K per K or ± 0.15% per K whichever is greater, at ambient: 0 to 85°C (32 to 185°F)
Box	± 0.1 K per K or ± 0.1% per K whichever is greater

Thermal Shock (within 20 min.)

LT	± 3.5 K at $\Delta T_{ambient}$ = 25 K (45°F) at target temperature of 50°C (45°F)

Emissivity

All models	0.100 to 1.100

Transmission

All models	0.100 to 1.000

3.2 Optical Specifications

Optical Resolution D:S

MID, MIC	2:1 or 10:1
MIH	10:1

At 90% energy in minimum and distance 400 mm (15.7 in.)

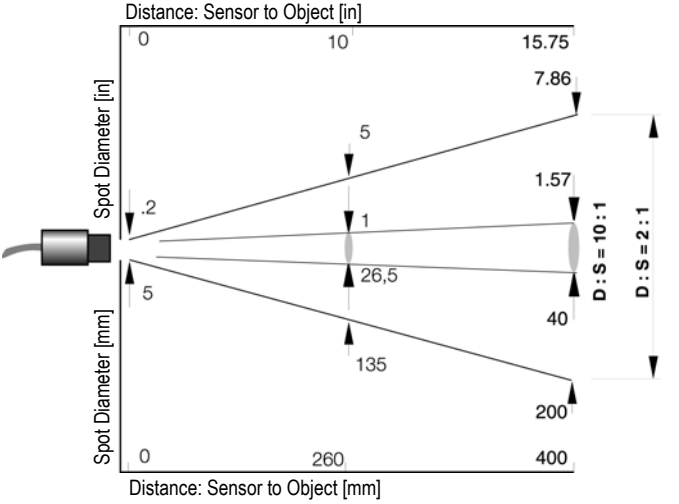


Figure 1: Spot Size Chart

3.3 Electrical Specifications

Power Supply

Voltage	12 to 24 VDC
Current	100 mA

Outputs

1. Output (OUT)	0 to 20 mA, or 4 to 20 mA, or 0 to 5 V, or Thermocouple (J or K)
2. Output (AMB)	0 to 5 V output for head ambient temperature (0 to 500°C, 32 to 932°F) or output for alarm relay (software enabled, only in conjunction with RS232/485)
mA Output	recommended loop impedance see Figure 9 on page 19.
0 to 5 V Outputs	min. load impedance 100 kΩ (a lower load impedance deteriorates the accuracy) output impedance 100 Ω short circuit resistant
Thermocouple	output impedance 20 Ω short circuit resistant

3.4 Environmental Specifications

Ambient Temperature	
MIH sensing head	0 to 180°C (32 to 356°F)
MIC sensing head	0 to 125°C (32 to 257°F)
MID sensing head	0 to 85°C (32 to 185°F)
MID with air cooling	-18 to 200°C (0 to 392°F)
Electronics box	0 to 65°C (32 to 150°F)
Storage Temperature	-18 to 85°C (0 to 185°F)
Rating (Head)	IP 65 (NEMA-4), only for models with an optical resolution of 10:1
Rating (Box)	IP 65 (NEMA-4)
Relative Humidity	10% to 95% non-condensing
EMI	IEC 801-3, level 3 max. cable length 3 m (118 in.)
Vibration (Head)	IEC 68-2-6: 3G´s, 11 to 200 Hz, any axis
Shock (Head)	IEC 68-2-27: 50G´s, 11 ms, any axis
Weight (Head)	50 g (2 oz.) with 1 m cable, stainless steel
Weight (Box)	270 g (10 oz.), die-cast zinc
Head Cable Material	
MID/MIC	PUR (Polyurethane), Halogen free, Silicone free
MIH	Teflon



Teflon develops poisonous gasses when it comes into contact with flames!

3.5 Dimensions

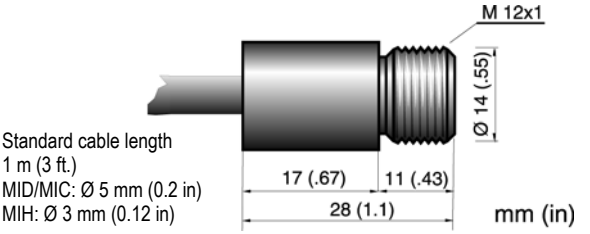


Figure 2: Dimensions of Sensing Head

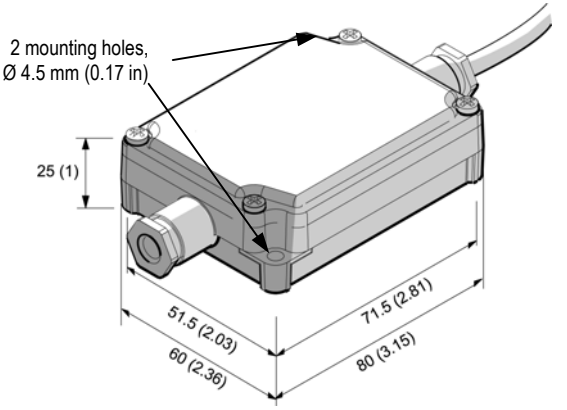


Figure 3: Dimensions of Electronic Box

3.6 Scope of Delivery

The scope of delivery includes the following:

- Sensing head
- 1 m head cable
- Mounting nut
- Electronic box
- Operating instructions

4 Basics

4.1 Measurement of Infrared Temperature

All surfaces emit infrared radiation The intensity of this infrared radiation changes according to the temperature of the object. Depending on the material and surface properties, the emitted radiation lies in a wavelength spectrum of approximately 1 to 20 µm. The intensity of the infrared radiation (”heat radiation”) is dependent on the material. For many substances this material-dependent constant is known. This constant is referred to as the ”emissivity value”.
Infrared

4.2 Emissivity of Target Object

To determine the emissivity of the target object refer to section 12.1 Determination of Emissivity on page 80. If emissivity is low, measured results could be falsified by interfering infrared radiation from background objects (such as heating systems, flames, fireclay bricks, etc. close beside or behind the target object). This type of problem can occur when measuring reflective surfaces and very thin materials such as plastic films and glass.
This measurement error can be reduced to a minimum if particular care is taken during installation, and the sensing head is shielded from these reflecting radiation sources.

4.3 Ambient Temperature

The sensing head was developed for the following ambient temperature ranges:

- MIH: 0 to 180°C (32 to 356°F)
- MIC: 0 to 125°C (32 to 257°F)
- MID: 0 to 85°C (32 to 185°F)

The MID can operate in ambient temperatures up to 200°C (392°F) with the air-cooling accessory.

4.4 Atmospheric Quality

If the lens gets dirty, infrared energy will be blocked and the instrument will not measure accurately. It is good practice to always keep the lens clean. The Air Purge Jacket helps keep contaminants from building up on the lens. If you use air purging, make sure a filtered air supply with clean dry air at the correct air pressure is installed before proceeding with the sensor installation.

4.5 Electrical Interference

To minimize electrical or electromagnetic interference or “noise” be aware of the following:

- Mount the unit as far away as possible from potential sources of electrical interference such as motorized equipment producing large step load changes.
- Use shielded wire for all input and output connections.
- Make sure the shield wires are earth grounded at one point.
- Sensor head shield braid should make direct contact around the cable circumference.

5 Installation

5.1 Positioning

Sensor location depends on the application. Before deciding on a location, you need to be aware of the ambient temperature of the location, the atmospheric quality of the location, and the possible electromagnetic interference in that location, according to the sections described above. If you plan to use air purging, you need to have an air connection available. Wiring and conduit runs must be considered, including computer wiring and connections, if used.

5.1.1 Distance to Object

The desired spot size on the target will determine the maximum measurement distance. To avoid erroneous readings the target spot size must completely fill the entire field of view of the sensor. Consequently, the sensor must be positioned so the field of view is the same as or smaller than the desired target size. For a list indicating the available optics, see section 3.2 Optical Specifications on page 6.

The actual spot size for any distance can be calculated by using the following formula. Divide the distance D by your model's D:S number. For example, for a unit with D:S = 10:1, if the sensor is 400 mm (15.7 in.) from the target, divide 400 by 10 (15.7 by 10), which gives you a target spot size of approximately 40 mm (1.57 in.).

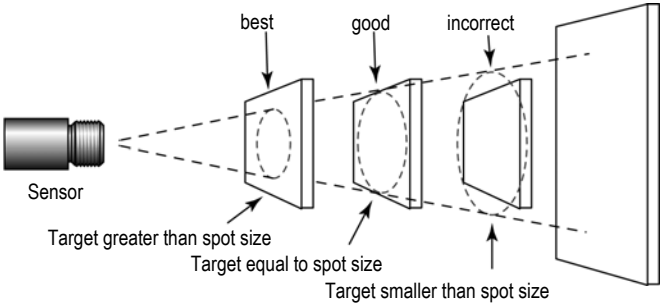


Figure 4: Proper Sensor Placement

5.2 Wiring

5.2.1 Sensor Head Cable

The manufacturer preinstalls the sensor head cable between sensor head and electronic box. It may be shortened but not lengthened.

Shortening the cable length by 1 m (3 ft.) causes a temperature error of – 0.1 K / m!

Do not bend the sensor head cable tighter than 25 mm / 1 in. (MID/MIC) and 15 mm / 0.6 in. (MIH) respectively!

5.2.2 Cable Preparations

You need to connect the power supply (12 to 24 VDC) and the signal output wires. Use only cable with outside diameter from 4 to 6 mm (0.16 to 0.24 in), AWG 24.

The cable must include shielded wires. It should not be used as a strain relief!

1. Cut about 40 mm (1.5 in) of the cable sheath (7) from the end of the cable. Caution: Do not cut into the shield!
2. Cut the shield (5) so about 5 mm (0.2 in) remains exposed from under the cable sheath (7). Separate the shield and spread the strands out. Shorten the inside insulation until you can separate the wires (6).
3. Strip 3 mm (0.15 in) of insulation from the wires (6).

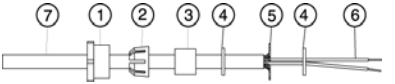


Figure 5: Cable Preparation

4. Open the electronic box by removing the four Phillips head screws and pulling off the lid. Unscrew the cap (1), and remove the plastic compression fitting (2), the rubber washer (3), which is inside the fitting, and the two metal washers (4).

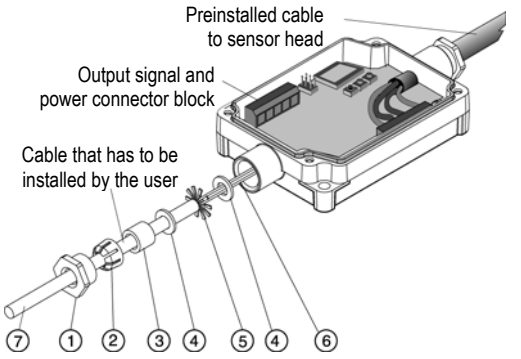


Figure 6: Connecting of Cables to the Electronic Box

5. Put the following on the cable (as shown in the figure above): the cap (1), the plastic compression fitting (2), the rubber washer (3) and one of the metal washers (4).
6. Spread the cable shield (5) and then slip the second metal washer (4) on the cable. Note that the shield must make good contact to both metal washers.
7. Slip the wires (6) into the electronic box far enough to connect to the power and output terminals.
8. Screw the cap (1) into the electronics box. Tighten snuggly. Do not over tighten.
9. Connect the wires (6) to the power and output terminals on the printed circuit board.

5.3 Outputs

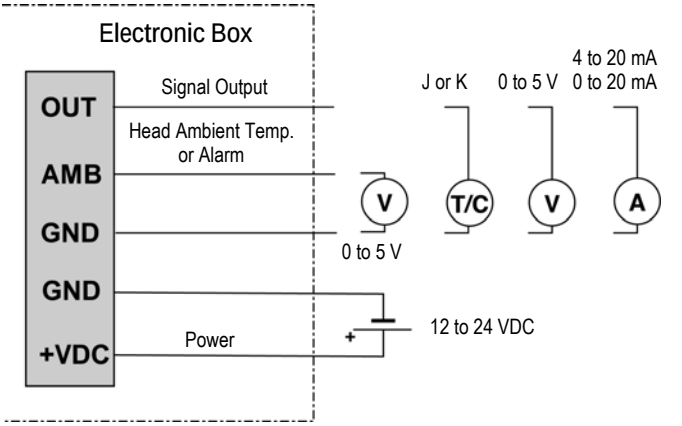


Figure 7: Signal Outputs and Power Supply

5.3.1 Signal Output

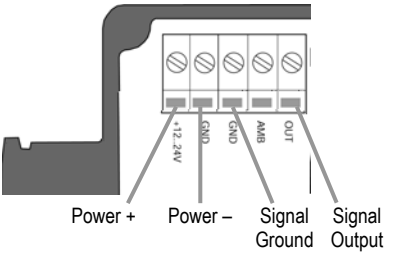


Figure 8: Wiring of the Signal Output (mA or V)

The signal output can be configured either as current or as voltage output.
The minimum load impedance for the 0 to 5 V output must be 100 kΩ.
The maximum current loop impedance for the 0/4 to 20 mA output can be 500 Ω, and the power supply and loop impedance must be matched as shown below.

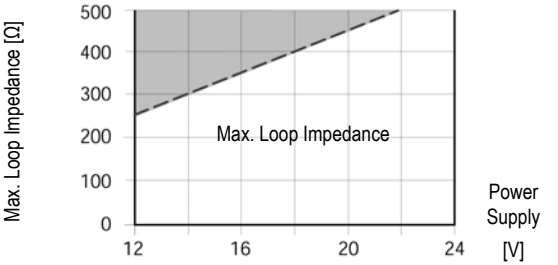


Figure 9: Max. Loop Impedance depending on Power Supply

5.3.2 Head Ambient Temp. / Alarm Output

This output can be configured either as output for the head ambient temperature (default configuration) or as an alarm output.

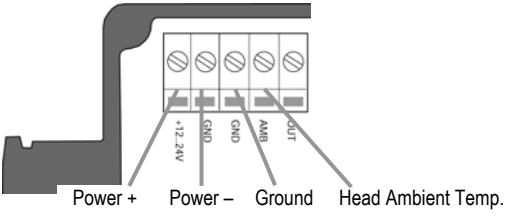


Figure 10: Wiring the Output for Head Ambient Temperature

The output range for the head ambient temperature is 0 to 500°C (32 to 932°F) with 10 mV /°C.
In case of an alarm the output switches between 0 V and 5 V. The alarm output is controlled by the target temperature or the sensing head temperature.

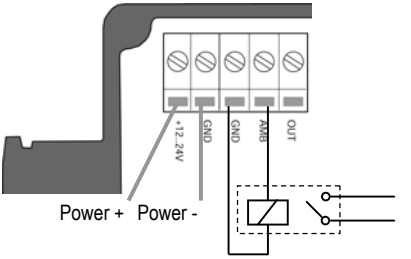


Figure 11: Wiring of the Alarm Output

You may use a solid state relay for the alarm output. The output is short circuit resistant with 100 Ω output impedance.

The alarm output is only enabled through the DataTemp MultiDrop software, see the software help for set up instructions.

5.3.3 Thermocouple Output

If you are using a J- or K- thermocouple you must install a compensation cable. The cable is available as an accessory (XXXCI1CB25 for Type J, XXXCI2CB25 for Type K) with a cable length of 7.5 m (24.6 ft.)
Connect the wires according to the following table:

J-Thermocouple		Power Supply	
+	–	+	–
white	red-white	red-yellow	yellow

Table 1: Wiring the Thermocouple J Compensation Cable

K-Thermocouple		Power Supply	
+	–	+	–
yellow	red-yellow	red-white	white

Table 2: Wiring the Thermocouple K Compensation Cable

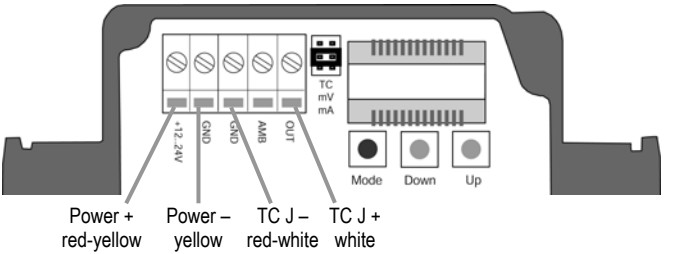


Figure 12: Wiring the Thermocouple J Compensation Cable

5.4 Inputs FTC

The three inputs FTC1, FTC2, and FTC3 are used for the external control of the unit.

All input functions are enabled through the DataTemp MultiDrop software only, see the software help for complete set up instructions!

	FTC1	FTC2	FTC3
Emissivity (analog control)	x		
Emissivity (digital control)	x	x	x
Ambient Background Temperature Compensation		x	
Trigger			x
Hold Function			x

Table 3: Overview to the FTC Inputs

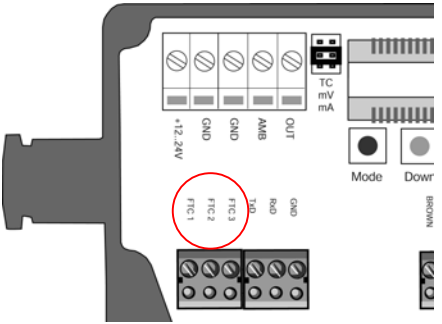


Figure 13: FTC Inputs on the Electronic Board

5.4.1 Emissivity Setting (analog controlled)

The input FTC1 can be configured to accept an analog voltage signal (0 to 5 VDC) to provide real time emissivity setting. The following table shows the relationship between input voltage and emissivity.

U in V	0.0	0.5	…	4.5	5.0
Emissivity	0.1	0.2	…	1.0	1.1

Table 4: Ratio between Analog Input Voltage and Emissivity

Example:
The process requires the setting of emissivity:

- for product 1: 0.90
- for product 2: 0.40

Following the scheme below, the operator needs only to switch to position "product 1" or "product 2".

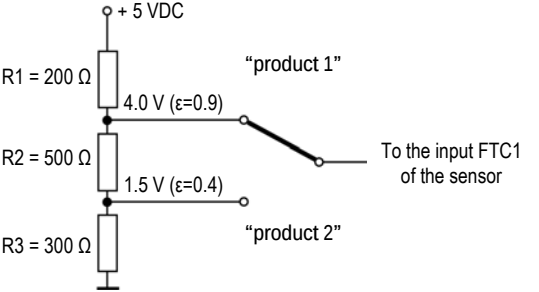


Figure 14: Adjustment of Emissivity at Input FTC1 (Example)

5.4.2 Emissivity Setting (digital controlled)

The sensor's electronics contains a table with 8 pre-installed settings for emissivity. To activate these emissivity settings, you need to have the inputs FTC1, FTC2, and FTC3 connected. According to the voltage level on the FTC inputs, one of the table entries will be activated.

0 = Low signal (0 V)
1 = High signal (5 V)

A non-wired input is considered as "High"!

Table entry	Emissivity (Examples)	FTC3	FTC2	FTC1
0	1.100	0	0	0
1	0.500	0	0	1
2	0.600	0	1	0
3	0.700	0	1	1
4	0.800	1	0	0
5	0.970	1	0	1
6	1.000	1	1	0
7	0.950	1	1	1

Figure 15: Digital Selection of Emissivity with FTC Inputs

The values in the table can only be changed by means of the DataTemp MultiDrop software.

5.4.3 Ambient Background Temperature Compensation

The sensor is capable of improving the accuracy of target temperature measurements by taking into account the ambient or background temperature. This feature is useful when the target emissivity is below 1.0 and the background temperature is significantly hotter than the target temperature. For instance, the higher temperature of a furnace wall could lead to hotter temperatures being measured especially for low emissivity targets.
Ambient background temperature compensation compensates for the impact of the reflected radiation in accordance to the reflective behavior of the target. Due to the surface structure of the target, some amount of ambient radiation will be reflected and therefore added to the thermal radiation that is collected by the sensor. The ambient background temperature compensation compensates the final result by subtracting the amount of ambient radiation measured from the sum of thermal radiation the sensor is exposed to.



The ambient background temperature compensation should always be activated in case of low emissivity targets measured in hot environments or when heat sources are near the target!

Three possibilities for ambient background temperature compensation are available:

- The **internal sensor head temperature** is utilized for compensation assuming that the ambient background temperature is more or less represented by the internal sensor head temperature. This is the default setting.
- If the background ambient temperature is known and constant, the user may give the known ambient temperature as a **constant temperature value**.

- Ambient background temperature compensation from a **second temperature sensor** (infrared or contact temperature sensor) ensures extremely accurate results. For example, the output of the second unit, set for mV output, could be connected to the FTC2 analog input (0 to 5 VDC corresponding to low end and high end of temperature range) is utilized for real time compensation, whereby both sensors must be set on the same temperature range.

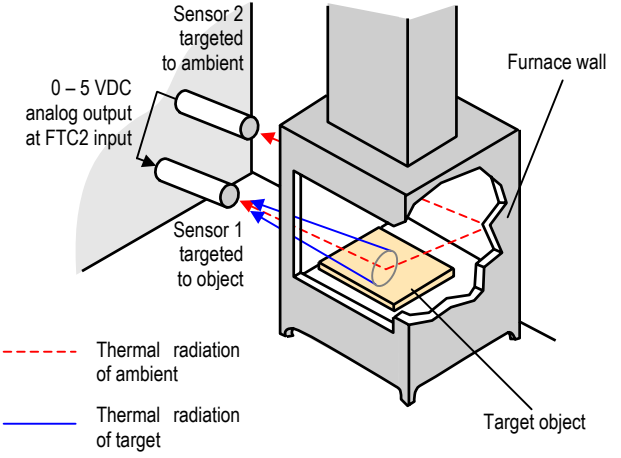


Figure 16: Principle of Ambient Background Temperature Compensation

5.4.4 Trigger and Hold Function

The FTC3 input can be used as external trigger in conjunction with the software trigger mode setting “Trigger” or “Hold”.

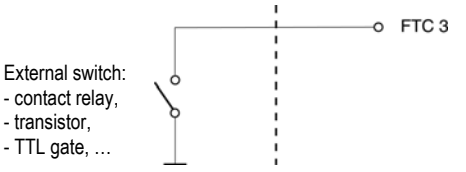


Figure 17: Wiring of FTC3 as External Input

Trigger: A logical low signal at the input FTC3 will reset the peak or valley hold function. As long as the input is kept at logical low level the software will transfer the actual object temperatures toward the output. At the next logical high level, the hold function will be restarted.

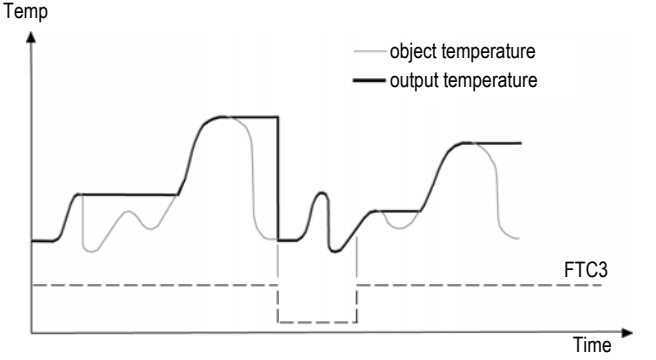


Figure 18: FTC3 for Resetting the Peak Hold Function

Hold: This mode acts as external generated hold function. A transition at the input FTC3 from logical high level toward logical low level will transfer the current temperature toward the output. This temperature will be written to the output until a new transition from high to low occurs at the input FTC3.

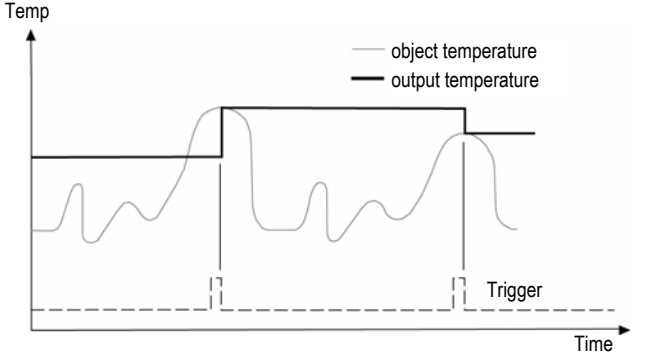


Figure 19: FTC3 for Holding the Output Temperature

5.5 Connecting to the PC via RS232

The RS232 interface comes with each model. Connect a single unit with a RS232 COM port by using the connection kit RAYMINCON.

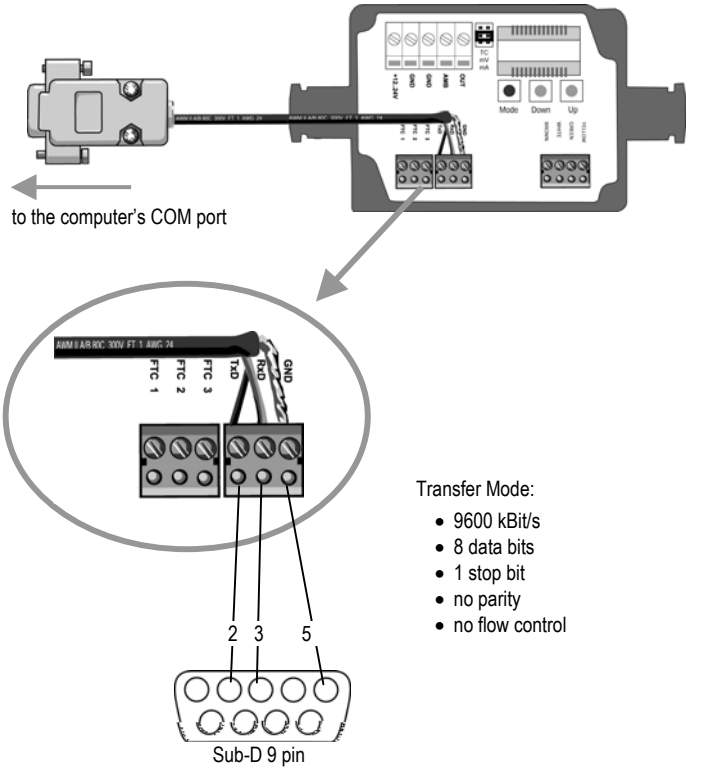


Figure 20: Connecting the RS232 cable

5.6 Installing of Multiple Sensors via RS485

The distance between the sensor and a computer can be up to 1200 m (4000 ft.) via RS485 interface. This allows ample distance from the harsh environment where the sensing head is mounted to a control room or pulpit where the computer is located.

The RS232/485 adapter comes with a power supply:
RAYMINCONV2 for 230 VAC
RAYMINCONV1 for 110 VAC

Connect the signal line as shown:

RS232/485 Adapter		**Electronic Box**
RxB	→	B
RxA	→	A

Do not run power supply in the same conduit as the RxA/RxB wires!

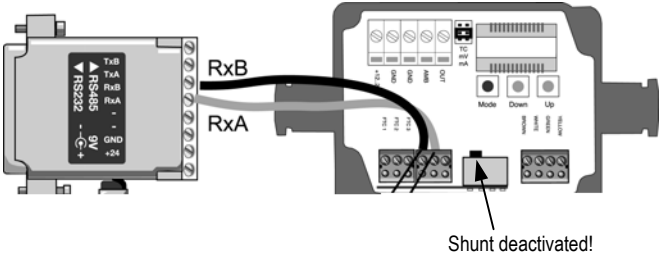


Figure 21: Wiring the RS485 Interface

For an installation of two or more sensors in a RS485 network, each sensor is wired parallel to the others.
You may connect up to 32 units. Make sure to deactivate the preset shunt resistor for all units **except** for the last one. The position of the switch to deactivate the shunt you can see on the electronic board in the figure above.

Before units are in a network the multidrop address needs to be defined. Each sensor must have a unique address!

The following figure illustrates the wiring of sensors in a multidrop installation.

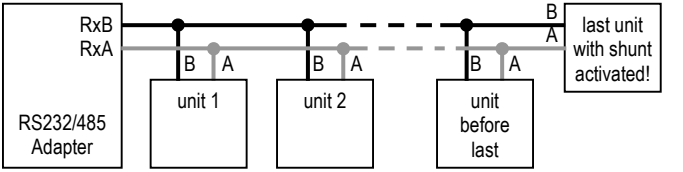
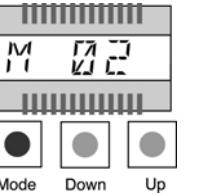


Figure 22: Wiring the RS485 Network

The address setting can be done either through buttons or through software alternatively.

Addressing through Buttons
Press the <Mode> button until "M" becomes visible. Use the <Down> and <Up> buttons until the requested address appears. Press the <Mode> button to acknowledge your selection.



Addressing through Software
Alternatively the sensor can be controlled by means of the optional available software DataTemp MultiDrop.

Go to the menu <Setup> <Sensor Setup>, and then select the register <Advanced Setup>. Use <Polling Address> for selecting the requested address.

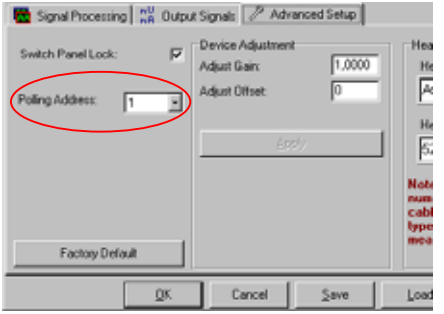


Figure 23: Address Setting

Step-by-step instructions for addressing RS-485 MI units:

1. Power the unit.
2. Using either the buttons or software, assign unique address to the sensor.
3. Power down the unit.
4. Repeat until all sensors have a unique address.
5. On the last unit in the network, activate the shunt resistor after the unit has been powered down.



Failure to use shielded RS-485 wire or activation of the shunt resistor when the unit is powered, can result in damage to the electronics!

6 Operation

Once you have the sensor positioned and connected properly, the system is ready for continuous operation.

The operation of the sensor can be done by means of the built-in control panel on the sensor's electronic board or by means of the software that came with your sensor optionally.

6.1 Control Panel

The sensor is equipped with a control panel in the sensor's electronic housing, which has setting/controlling buttons and an LCD display. The actual function mode is shown on the display with a specific mode symbol.

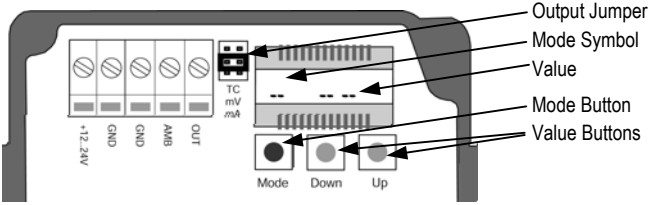
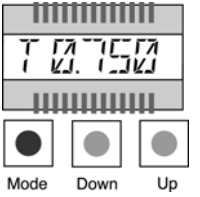


Figure 24: Control Panel

6.2 Setting of Modes

You can easily determine the unit's mode or parameter by doing the following:

Press the <Mode> button until the symbol for the actual set mode appears in the display, e.g. <T> for setting the transmission, see Table 5: Available Modes, on page 36.
Use the <Down/Up> buttons until the requested value comes into view.



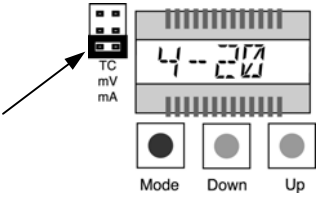
Display	Mode	Range
C	Target Temperature* (effected by signal processing)	not adjustable
A	Head Ambient Temperature	not adjustable
T	Target Temperature (not effected by signal processing)	not adjustable
	Output Mode	mV mV output (default) TCK thermocouple type K output TCJ thermocouple type J output 4 - 20 4 - 20 mA current loop 0 - 20 0 - 20 mA current loop
E	Emissivity	0.100 ... 1.000 (default: 0.950)
T	Transmission	0.100 ... 1.000 (default: 1.000)
A	Signal processing: Average**	0.100 ... 999.0
P	Signal processing: Peak Hold**	0.100 ... 998.9 999 = infinite (P ∞)
V	Signal processing: Valley Hold**	0.100 ... 998.9 999 = infinite (V ∞)
L	Low end of range	L = -40 ... 600**** (default: 0)
H	High end of range	H = -40 ... 600**** (default: 500)
U	Temperature Unit	°C or °F (default: °C)
M	Multidrop Address***	1 – 32, --- for address 0 (single unit)

* *appears automatically after 10 s without any action*
** *not simultaneously*
*** *only for units with RS485 interface*
**** *temperatures according to LT head*

Table 5: Available Modes

6.3 Setting the Output Jumper

In addition to the set mode in the unit, see section 6.2 Setting of Modes on page 35, the unit's outputs must be configured by switching the <Output> jumper in accordance to the requested output function (mA, mV, TC). E.g. for the "4 to 20 mA" output, the <Output> jumper must be set to the bottom position labeled with "mA".



6.4 Post Processing

6.4.1 Averaging

Averaging is used to smooth the output signal. The signal is smoothed depending on the defined time basis, whereby the output signal tracks the detector signal with significant time delay but noise and short peaks are damped. Use a longer average time for more accurate damping behavior. The average time is the amount of time the output signal needs to reach 90% magnitude of an object temperature jump.

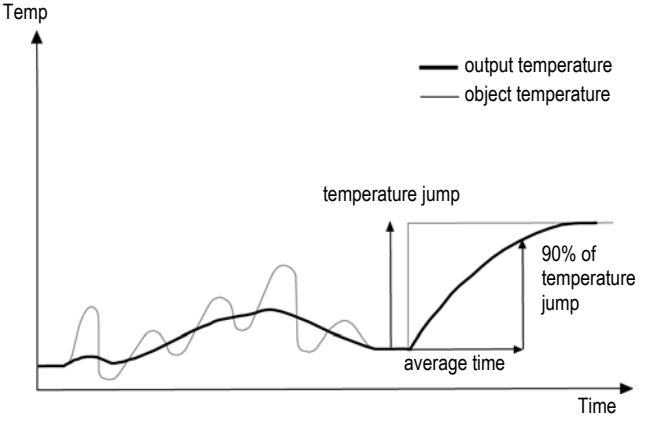


Figure 25: Averaging

A low level input (GND) at external input FTC3 will promptly interrupt the averaging and will start the calculation again.

Attention: The disadvantage of averaging is the time delay of the output signal. In case of having a temperature jump at the input (hot

object), the output signal reaches only 90% magnitude of the actual object temperature after the defined average time.

6.4.2 Peak Hold

The output signal follows the object temperature until a maximum is found. Once the hold time is exceeded the output signal, tracks and output the actual object temperature and the algorithm will start over again. The range for the hold time is 0.1 to 998.9 s.

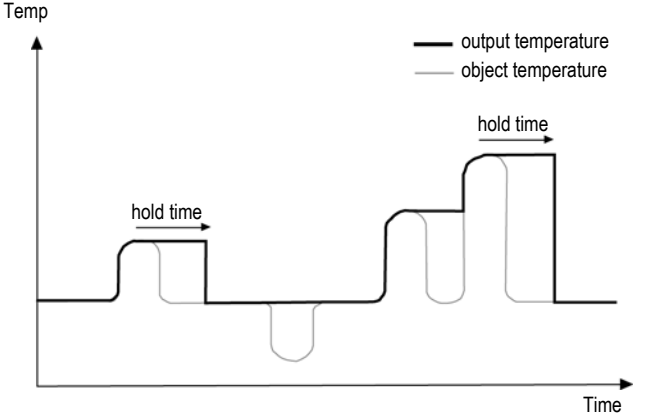


Figure 26: Peak Hold

A defined hold time of 999 s (symbol "∞" in the display) will put the device into continuous peak detection mode.
A low level input (GND) at external input FTC3 will promptly interrupt the hold time and will start the maximum detection again.

6.4.3 Valley Hold

The output signal follows the object temperature until a minimum is found. Once the hold time is exceeded the output signal, tracks and output the actual object temperature and the algorithm will start over again. The range for the hold time is 0.1 to 998.9 s.

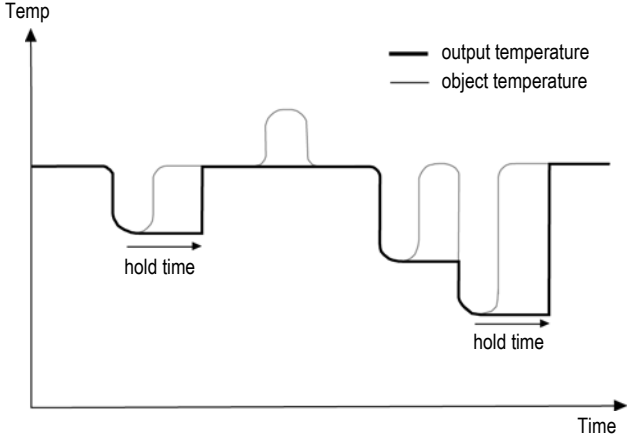


Figure 27: Valley Hold

A defined hold time of 999 s (symbol "∞" in the display) will put the device into continuous valley detection mode.
A low level input (GND) at external input FTC3 will promptly interrupt the hold time and will start the minimum detection again.

6.4.4 Advanced Peak Hold

This function searches the sensor signal for a local maximum (peak) and writes this value to the output until a new local maximum is found. Before the algorithm restarts searching for a local maximum, the object temperature has to drop below a predefined threshold. If the object temperature raises above the held value which has been written to the output so far, the output signal follows the object temperature again. If the algorithm detects a local maximum while the object temperature is currently below the predefined threshold the output signal jumps to the new maximum temperature of this local maximum. Once the actual temperature has passed a maximum above a certain magnitude, a new local maximum is found. This magnitude is called hysteresis.

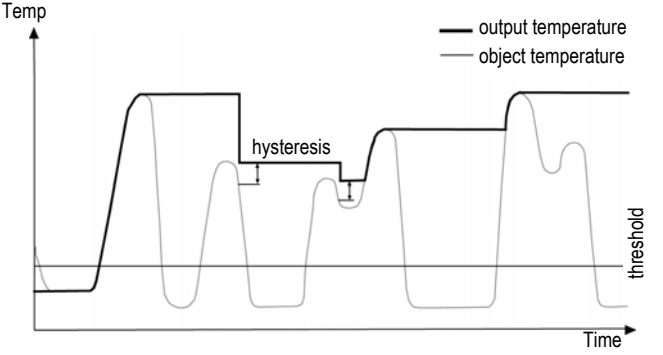


Figure 28: Advanced Peak Hold

The advanced peak hold function is only adjustable by means of the DataTemp MultiDrop Software.

6.4.5 Advanced Valley Hold

This function works similar to the advanced peak hold function, except it will search the signal for a local minimum.

6.4.6 Advanced Peak Hold with Averaging

The output signal delivered by the advanced peak hold functions tends to jump up and down. This is due to the fact, that only maximum points of the otherwise homogenous trace will be shown. The user may combine the functionality of the peak hold function with the averaging function by choosing an average time, thus, smoothing the output signal for convenient tracing.

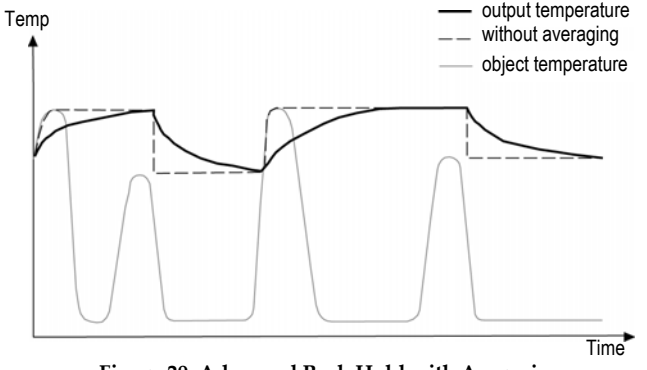


Figure 29: Advanced Peak Hold with Averaging

The advanced peak hold function with averaging is only adjustable by means of the DataTemp MultiDrop Software.

6.4.7 Advanced Valley Hold with Averaging

This function works similar to the advanced peak hold function with averaging, except it will search the signal for a local minimum.

6.5 Factory Defaults

For activating the unit's factory default values press the <Mode/Up> buttons on the electronic board simultaneously. The factory default values are to be found in section 11.8 Command Set on page 76.

7 Options

Options are items that are factory installed and must be specified at time of order. The following are available:

- Longer cable lengths: 3 m / 9.8 ft. (…CB3), 8 m / 26.2 ft. (…CB8), 15 m / 49.2 ft. (…CB15)
- RS485 serial interface (…4), for multidrop networks or long distances
- Box lid with view port (…V)

8 Accessories

8.1 Overview

A full range of accessories for various applications and industrial environments are available. Accessories include items that may be ordered at any time and added on-site:

- Adjustable Mounting Bracket (XXXMIACAB)
- Fixed Mounting Bracket (XXXMIACFB)
- Air Purging Jacket (XXXMIACAJ)
- Air Cooling System (XXXMIACCJ)
- Right Angle Mirror (XXXMIACRAJ, XXXMIACRAJ1)
- Box Lid (XXXMIACV)
- Protective Window (XXXMIACPW)
- Protective Window, transmission already set in the unit (XXXMIACPWI)
- PC connection kit for models with RS232, including DataTemp MultiDrop Software (RAYMINCON)
- PC connection kit for models with RS485, including DataTemp MultiDrop Software and RS232/485 converter:
  110 VAC (RAYMINCONV1)
  230 VAC (RAYMINCONV2)

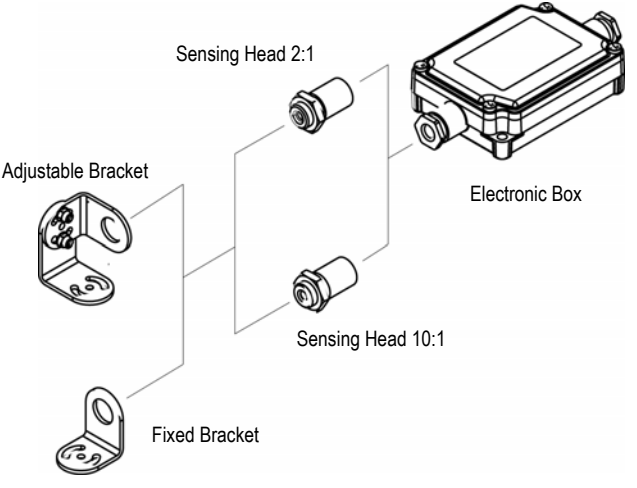


Figure 30: Standard Mounting Accessories

8.2 Adjustable Mounting Bracket

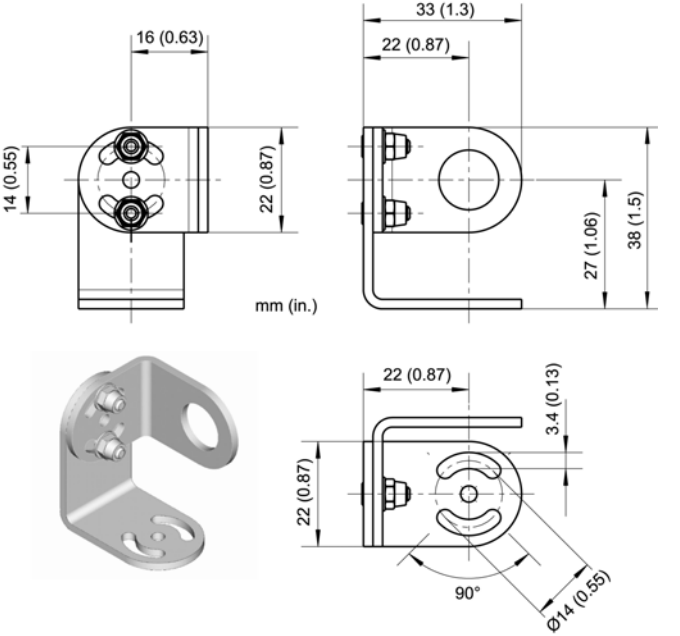


Figure 31: Adjustable Mounting Bracket (XXXMIACAB)

8.3 Fixed Mounting Bracket

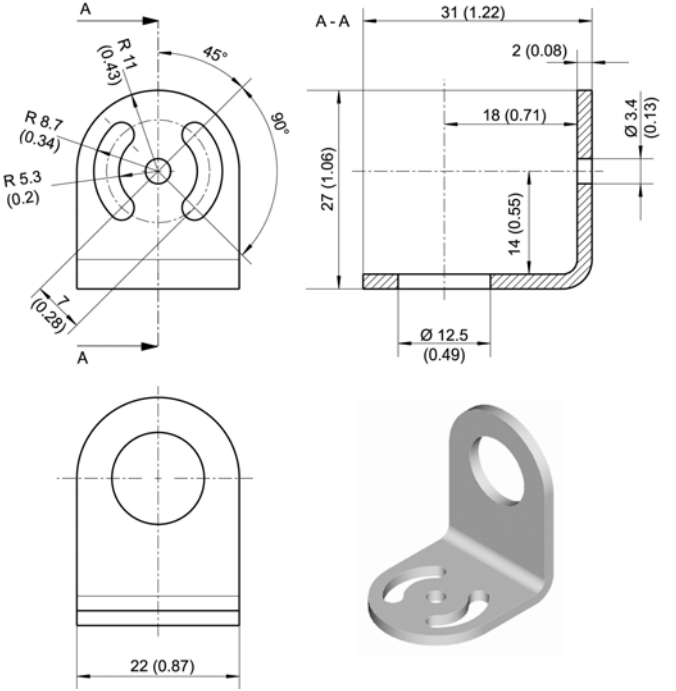


Figure 32: Fixed Mounting Bracket (XXXMIACFB)

8.4 Air Purging Jacket

The air purge jacket is used to keep dust, moisture, airborne particles, and vapors away from the sensing head. Clean, oil free air is recommended. The air purge jacket withstands ambient temperatures up to 180°C (356°F) and should not be used for cooling purposes. The recommended air flow rate is 30 to 60 l / min (0.5 to 1 cfm). The max. pressure is 5 bar.

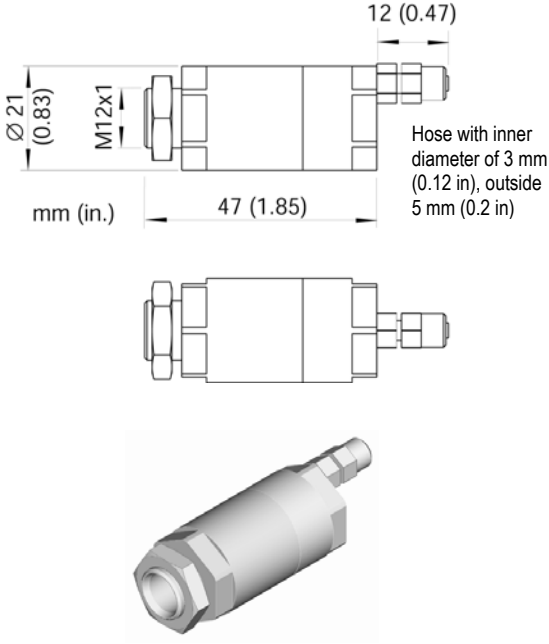


Figure 33: Air Purging Jacket (XXXMIACAJ)

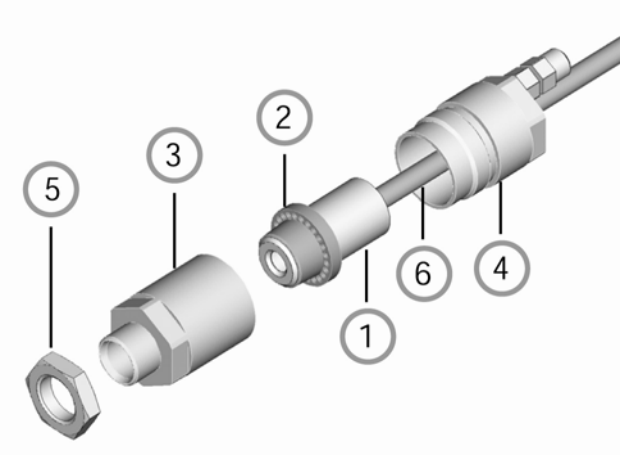


Figure 34: Mounting the Air Purge Jacket

1. Remove the sensor **(1)** and cable from the electronic box by disconnecting the wires from the electronic box.
2. Open the Air Purging Jacket **(3, 4)** and screw the white plastic fitting **(2)** onto the sensor up to the end of the threads, do not over tighten!
3. Slip the cable **(6)** through the backside **(4)** of the jacket.
4. Close the Air Purging Jacket **(3, 4)** and reconnect the wires to the electronic box and apply the mounting nut **(5).**

8.5 Air Cooling System

The sensing head can operate in ambient temperatures up to 200°C (392°F) with the air-cooling system. The air-cooling system comes with a T-adapter including 0.8 m (7.5 in) air hose and insulation. The T-adapter allows the air-cooling hose to be installed without interrupting the connections to the box.
The air-cooling jacket may be combined with the right angle mirror.

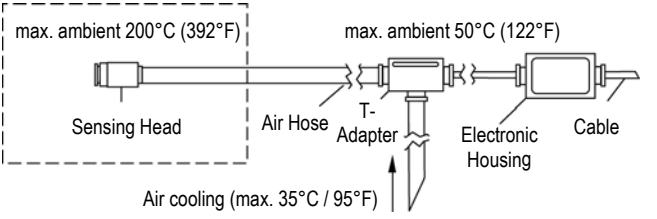


Figure 35: Air Cooling System

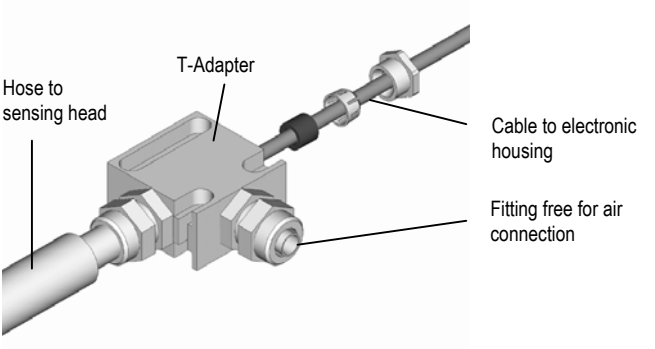


Figure 36: Connecting the T-Adapter (XXXMIACCJ)

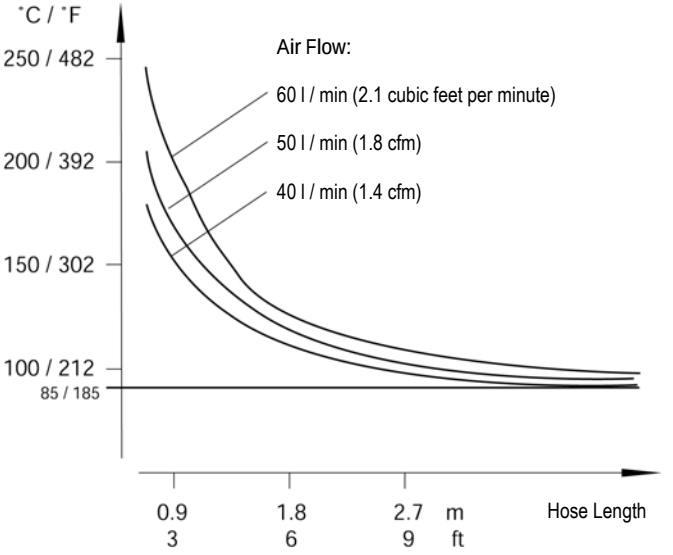


Figure 37: Maximum Ambient Temperature depending on Air Flow and Hose Length

Note: "Hose Length" is the length of hose exposed to high ambient temperature (not the overall length of the hose).

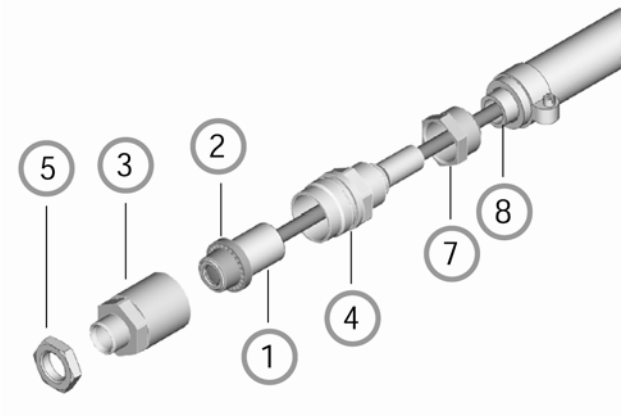


Figure 38: Air Cooling System: Purging Jacket

The Air Cooling System consists of:

(1) sensing head
(2) inner plastic fitting (air purging jacket)
(3) front part of the air-purging jacket
(4) back part of the air-purging jacket
(5) mounting nut
(6) preinstalled cable between sensor and box, leading through the T-adapter
(7) hose connecting nut
(8) inner hose
(9) outer hose
(10) T-adapter
(11) rubber washer
(12) plastic compression fitting
(13) cap

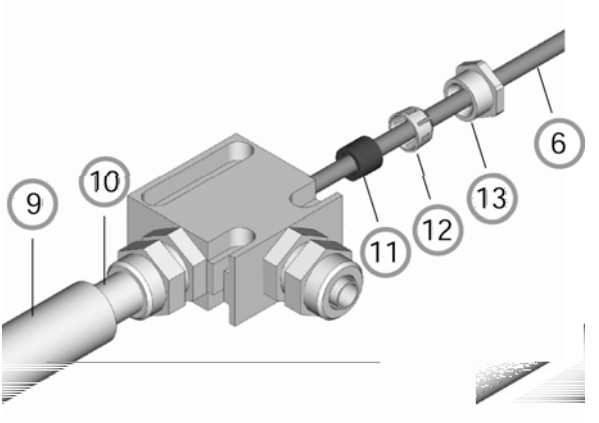


Figure 39: Air Cooling System: T-Adapter

Hose:
inner Ø: 9 mm (0.35 in)
outer Ø: 12 mm (0.47 in)

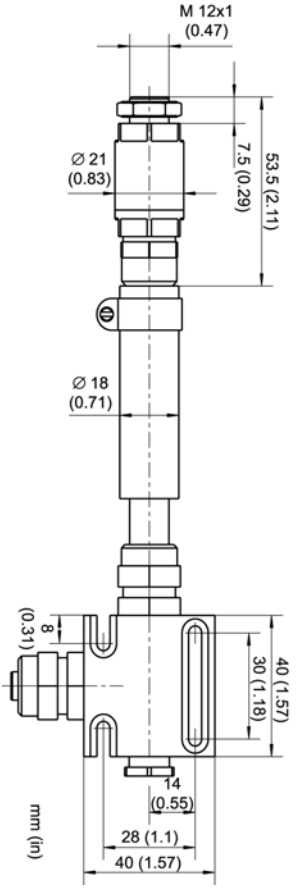


Figure 40: Dimensions of Air Cooling System

8.6 Right Angle Mirror

The right angle mirror comes in two different versions:

XXXMIACRAJ	right angle mirror as accessory for air purging jacket or air cooling system
XXXMIACRAJ1	right angle mirror with integrated air purging

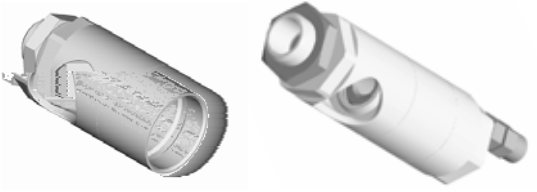


Figure 41: Right Angle Mirror XXXMIACRAJ (left), Right Angle Mirror with Air Purging XXXMIACRAJ1 (right)

The right angle mirror withstands ambient temperatures up to 180°C (356°F).

For mounting the right angle mirror (XXXMIACRAJ) see section 8.4 Air Purging Jacket on page 50. However, instead of using the front part of the air purging jacket **(3)**, mount the right angle mirror.

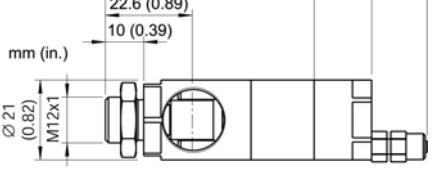


Figure 42: Right Angle Mirror (* with Air Purging)

8.7 Box Lid



Figure 43: Box Lid with View Port for Post Installations (XXXMIACV)

8.8 Protective Window

The protective window can be used to protect the sensing head from dust and other contamination. This should be applied especially for sensors without a lens. These are all models with an optical resolution of 2:1.

The protective window is made from non-poisonous zinc sulfide, with a transmission factor of 0.75 ± 0.05. It has an outer diameter of 17 mm (0.67 in). The protective window can be directly screwed to the sensing head. It withstands ambient temperatures up to 180°C (356°F).

For correct temperature readings, the transmission of the protective window must be set via the control panel in the sensor's electronic housing, see section 6.2 Setting of Modes on page 35!



Figure 44: Protective Window (XXXMIACPW)

9 Maintenance

Our sales representatives and customer service are always at your disposal for questions regarding application assistance, calibration, repair, and solutions to specific problems. Please contact your local sales representative if you need assistance. In many cases, problems can be solved over the telephone. If you need to return equipment for servicing, calibration, or repair, please contact our Service Department before shipping. Phone numbers are listed at the beginning of this document.

9.1 Troubleshooting Minor Problems

Symptom	Probable Cause	Solution
No output	No power to instrument	Check the power supply
Erroneous temperature	Faulty sensor cable	Verify cable continuity
Erroneous temperature	Field of view obstruction	Remove the obstruction
Erroneous temperature	Window lens	

9.2 Fail-Safe Operation

The Fail-Safe system is designed to alert the operator and provide a safe output in case of any system failure. The sensor is designed to shutdown the process in the event of a set-up error, system error, or a failure in the sensor electronics.



The Fail-Safe circuit should never be relied on exclusively to protect critical processes. Other safety devices should also be used to supplement this function!

When an error or failure does occur, the display indicates the possible failure area, and the output circuits automatically adjust to their preset levels, see the following tables.

Error Codes for the Outputs

Symptom	mV	0 to 20 mA	4 to 20 mA	TC-K	TC-J
Temperature over range	5 V	21 mA	21 mA	-	-
Temperature under range	0 V	2.5 mA	0 mA	-	-
Defect of the internal head ambient temperature probe	5 V	21 mA	21 mA	> 1200°C (2192 °F)	> 1200°C (2192 °F)

Table 7: Error Codes (Outputs)

Error Codes via RS232/485

Output	Error Code Description
T------	Invalid temperature reading
T>>>>>>	Temperature over range
T<<<<<<	Temperature under range

Table 8: Error Codes (via RS232/485)

Error Codes for the LCD Display

Display	Error Code Description
----C	Invalid temperature reading
H-ERR	Wrong sensing head
B-ERR	Wrong parameter setting (box)
OVER	Temperature over range
UNDER	Temperature under range
2.15	Firmware revision number, after reset of the unit (2 seconds)

Table 9: Error Codes (LCD Display)

9.3 Sensing Head Exchange

MIH sensing heads and electronic boxes can not be interchanged with MID/MIC sensing heads and electronic boxes!

The head exchange requires to type in the new sensing head calibration data printed on the cable as follows:

1. To exchange the sensing head, disconnect the power of the unit.
2. Connect the wires for the new sensing head according to the color description on the printed circuit board.
3. Switch the power for the unit to ON.
4. Press simultaneously the **<Mode/Down/Up>** buttons.
5. Four characters appear in the display (former values). Type in the new designator **(A)** using the **<Down/Up>** buttons. Press the **<Mode>** button.
6. The second block of four characters appears in the display (former values). Type in the new designator **(B)** using the **<Down/Up>** buttons. Activate your settings by pressing the **<Mode>** button.



Figure 45: Sensing Head Calibration Data printed on the Cable (e.g. Head with two blocks of 4 numbers)

For MIH models and specially modified models (like G5 or MTB), four blocks of four characters are used.
Alternatively you also can use the DataTemp MultiDrop software for typing in the new sensing head calibration data.

10 Software

For use with RS232 or RS485 models, DataTemp MultiDrop software allows access to the extended digital features of the MID with an easy-to-use interface. Compatible with WIN 95/98/NT/2000/XP, DataTemp MultiDrop provides for sensor setup, remote monitoring, and simple data logging for analysis or to meet quality record-keeping requirements.

Additional features configurable with optional RS232 or optional RS485 communications and DataTemp MultiDrop Software:

- 5V alarm signal triggered by target temperature or ambient head temperature
- Eight-position "recipe" table that can be easily interfaced to an external control system
- External reset signal input for signal processing
- External inputs for analog emissivity adjustment or background radiation compensation
- Remote digital communication and control of up to 32 sensors in an RS485 multidrop configuration

For more detailed information, see the comprehensive software help of the DataTemp MultiDrop.

11 Programming Guide

This section explains the sensor's communication protocol. A protocol is the set of commands that define all possible communications with the sensor. The commands are described along with their associated ASCII command characters and related message format information. Use them when writing custom programs for your applications or when communicating with your sensor with a terminal program.

11.1 Transfer Modes

The unit's serial interface is either RS232 or RS485, depending on the model.

Settings: transfer rate: 9.6 kBaud, 8 data bits, 1 stop bit, no parity, flow control: none (half duplex mode).

There are two possible transfer modes for the serial interface:

Poll Mode: By user interface control, a parameter will be set or requested.

Burst Mode: A pre-defined data string ("burst string") will be transferred as fast as possible as long as the burst mode is activated. The data will be transferred in one direction only, from the unit to the user interface.

V=P	"P" starts the Poll mode (allows to request or to set parameters)
V=B	"B" starts the Burst mode (data will be transferred as fast as possible; necessary: data string definition – "Burst string")
$=UTIE	"$" sets the parameter combination ("burst string") "U" unit (°C or °F) "T" temperature value "I" internal temperature of the sensing head "E" emissivity
?X$	gives the burst string parameters while in poll mode

Return from the burst mode to the poll mode:

If the poll mode shall be activated while the burst mode is still active, send a character and within the following 3 seconds the command V=P.

11.2 General Command Structure

Requesting a parameter (Poll Mode)

?ECR "?" is the command for "Request"
"E" is the parameter requested
"CR" (carriage return, 0Dh) is closing the request.
Remark: It is possible to close with "CR" "LF", 0Dh, 0Ah, but not necessary.

Setting a parameter (Poll Mode)

The parameter will be stored into the device EEPROM.

E=0.975CR "E" is the parameter to be set
"=" is the command for "set a parameter"
"0.975" is the value for the parameter
"CR" (carriage return, 0Dh) is closing the request
Remark: It is possible to close with "CR" "LF", 0Dh, 0Ah, but not necessary.

Setting a parameter without writing into the EEPROM (Poll Mode)

This function is for test purposes only.

E#0.975CR "E" is the parameter to be set
"#" is the command for "set parameter without writing into the EEPROM"
"0.975" is the value for the parameter
"CR" (carriage return, 0Dh) is closing the request.
Remark: It is possible to close with "CR" "LF", 0Dh, 0Ah, but not necessary.

Device response format:

!E0.975CRLF "!" is the parameter for "Answer"
"E" is the parameter
"0.975" is the value for the parameter
"CR" „LF" (0Dh 0Ah) is closing the answer.

After switching the power to "ON", the device is sending a notification:

#XICRLF "#" is the parameter for "Notification"
"XI" is the value for the notification (here "XI"; unit switches to "ON")
"CR" "LF" (0Dh 0Ah) is closing the answer.

Error message

Syntax Error "" is the character for "Error"

11.3 Device Information

This information is factory installed, read only.

Command	Description	Answer (Example)
?XU	Device name	"XUMILT"
?DS	Remark (e.g., for specials)	"!DSRAY"
?XV	Serial Number	"!XV0A0027"
?XR	Firmware Revision Number	"!XR2.08"
?XH	Maximum Temp. Range: e.g. for LT head	"!XH0600.0"
?XB	Minimum Temp. Range: e.g. for LT head	"!XB-040.0"

Table 1: Device Information

11.4 Device Setup

11.4.1 Temperature Calculation

U=C	unit for the temperature value
E=0.950	Emissivity setting (Caution: according to the settings for "ES", see section 11.4.2 Emissivity Setting and Alarm Setpoints on page 69.)
XG=1.000	Setting for transmission

For the calculation of the temperature value, it is possible to set an offset (relative number to be added to the temperature value), and a gain value.

DG=1.0000	Gain adjustment for the temperature signal
DO=0	Offset adjustment for the temperature signal

In case the ambient temperature is not requested by the internal head temperature, you must set the ambient temperature values as follows:

A=250.0	Ambient temperature (example)
AC=1	Control ambient background temp. compensation

11.4.2 Emissivity Setting and Alarm Set points

The device allows three choices for the emissivity setting and two for the alarm output setting.

ES	**Selection of the emissivity setting.**
ES=1	Emissivity set by a constant number according to the „E" command
ES=E	Emissivity set by a voltage on FTC1 (analog input)
ES=D	Emissivity set by the entries in a table (selected by digital inputs FTC1 – FTC 3)
?CE	asks for the emissivity value that is actually used for temperature calculation

There are eight entries possible for emissivity setting **(1)** and a related set point (threshold) **(2).** To be able to write or read these values, use the following commands:

EP=2 set pointer for table entry, e.g. to line 2 **(3)**
RV=0.600 set the emissivity value for line 2 to 0.600 **(4)**
SV=220.0 set the set point (threshold) for line 2 to 220.0 **(5)**

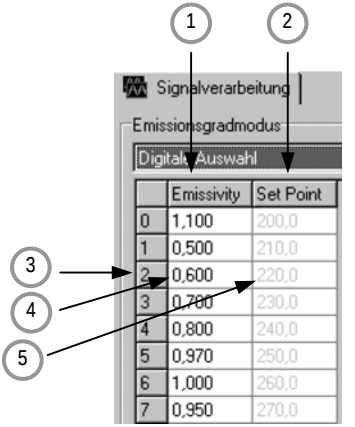


Figure 46: Table for Emissivity and Set Points

To activate these emissivity settings, you need to have the 3 external inputs (FTC) connected. According to the digital combination on the FTC wires, one of the table entries will be activated, see section 5.4.2 Emissivity Setting via Digital Selection on page 25.

11.4.3 Post Processing

The following parameters can be set to determine the post processing mode, see section 6.4 Post Processing on page 38.

P=5	peak hold, hold time: 5 s
F=12.5	valley hold, hold time: 12.5 s
G=10	averaging, average time (90%): 10 s
XY=3	advanced peak hold, hysteresis: 3 K
XY=-2	advanced valley hold, hysteresis: 2 K
	Advanced Peak/Valley Hold with Averaging:
C=250	threshold: 250°C
AA=15	averaging time (90%): 15 s

11.5 Dynamic Data

All temperature related information is calculated 128 times a second. To request the dynamic data, following commands are available:

?T	target temperature
?I	internal temperature of the sensing head
?XJ	internal temperature of electronics housing
?Q	energy value of the infra-red temperature
?XT	trigger set point (active/inactive) for the FTC3 input

To check for resets (e.g. power shut down) use the command XI. Notice, after a reset the unit is new initialized.

?XI	asks for the reset status
!XI0	no reset occurred
!XI1	a reset occurred, new initialization of the unit
XI=0	sets the reset status back to 0

11.6 Device Control

11.6.1 Output for the Target Temperature

The signal output can be set to 4 – 20 mA, 0 – 20 mA or mV. If current output is activated, the output can provide a predefined current:

XO=4	output mode to 4 – 20 mA
O=13.57	output of a constant current at 13.57 mA
O=60	switches back to the temperature controlled output

11.6.2 Analog Output, Scaling

According to the temperature range of the model, it is possible to set a maximum voltage/current value according to a temperature value (e.g., the maximum current 20 mA shall represent 200°C / 392°F). The same setting is possible for the minimum value.

H=500	the maximum current/voltage value is set to 500°C
L=0	the minimum current/voltage value is set to 0°C

Remark: You cannot set this value for thermocouple output. The minimum span between the maximum / minimum settings is 20 K.

11.6.3 Alarm Output

The second output channel can be set in different modes, see section 5.3.2 Head Ambient Temp. / Alarm Output on page 20.

- Internal sensing head temperature
- Alarm output

K=7	internal sensing head temperature
K=4	alarm output for object temperature, 0 V in case of no alarm
XS=125.3	threshold setting to 125.3°C (if U=C is set)

11.6.4 Factory default values

It is possible to reset the unit to the default values.

XF factory default values will be set

11.6.5 Lock Mode

The access to the unit is possible via serial interface (software) and via the direct user input (mode buttons, LCD display). It is possible to lock the buttons. This allows access the unit only via software.

J=L direct user input via mode buttons denied

Alternatively the unit can be unlocked by pressing the <Mode/Up> buttons simultaneously for three seconds.

11.6.6 Mode Setting for the Digital Input FTC3

The digital input FTC3 (see section 5.4.4 Trigger and Hold Function on page 28) can be used as follows:

XN=T FTC3 as trigger
XN=H FTC3 with hold function

11.6.7 Changing the Sensing Head Calibration Data

If it is necessary to exchange the sensing head, you must set the calibration data for the new sensing head:

XZ=0123 4567 FFFF FFFF according to the head calibration data

For MID/MIC-models the last eight numbers are not used and must be set to „F“ like shown in the example above. For MIH-models and specials (like MTB or G5) all sixteen numbers are used.

11.6.8 Ambient Background Temperature Compensation

In case of compensating the ambient background temperature, the following modes are available:

AC=0 no compensation
AC=1 compensation with a constant temperature value set with command A.

AC=2 compensation with an external voltage signal at the analog input FTC2 (0 V – 5V corresponds to low end and high end of temperature range), current ambient temperature is readable with command A.
Note: The mode AC = 2 does not function in case of setting the command ES = D!

For more information regarding the ambient background temperature compensation see section 5.4.3 Ambient Background Temp. Compensation en page 26.

11.7 Multiple Units (Multidrop Mode, RS485)

Up to 32 units can be connected within a RS485 network, see section 5.6 Installing of Multiple Sensors via RS485 on page 31. To direct a command to one unit among the 32 possible, it is necessary to „address“ a command. Therefore, a 3-digit number is set prior the command. The 3-digit number is determined between 001 and 032. Exception: Broadcast command.
If a command is transferred, starting with the 3-digit number 000, all units (with addresses from 001 to 032) connected will get this command – without to send an answer.
Note: A unit with the address 000 is a single unit and not in multidrop mode.

XA=024 will set address to 24 (unit must not be in multidrop mode)

Changing an address:
(e.g. the address is change from 24 to 17)

command	answer
„017?E“	„017E0.950“
„017XA=024“	“017XA024” setting of a new address
„024?E“	„024E0.950“

Example for the broadcast command:

command	answer
“024?E”	“024E0.950”
“000E=0.5”	will be executed from all units, no answer
“024?E”	“024E0.500”
“012?E”	“012E0.500”

11.8 Command Set

Description	Char	Format	P	B	S	Legal values	Factory default	LCD
Poll parameter	?	?X/?XX	*			?T		
Set parameter	=	X/XX=...			*	E=0.85		
Set parameter without EEPROM storage	#	X/XX#			*	E#0.85		
Multidrop addressing		001?E	*		*	answer: 001!E0.95		
Error message	*					*Syntax error		
Acknowledge message	!					!P010		
Burst string format	$		*		*	(3)	UTEI	
Ambient background temp. compensation	A	nnn.n	*	*	*	(1)	(6)	
Advanced hold with average	AA	nnn.n	*		*	000.0 – 999 s	000.0 s	
Control ambient background temp. compensation	AC	n	*		*	0 = head temp., 1 = via number, 2 = via external input	0	
Advanced hold threshold	C	nnn.n	*		*	in current scale(C / F)	300	
Currently calculated emissivity	CE	n.nnn	*					
Current calculation setpoint / relay function	CS	nnn.n	*			In current scale (C / F)		
Device adjustment gain	DG	n.nnn	*		*	0.8000 1.2000	1.0000	
Device adjustment offset	DO	nnn	*		*	-200 +200	0	
Device special	DS	XXX	*			z.B. !DSRAY		
Emissivity internal (10)	E	n.nnn	*	*	*	0.100 – 1.100	0.950	E
Error Code	EC	nnnn	*			Hex value of ErrCode		
Presel. emissivity pointer (10)	EP	n	*		*	0 – 7	7	

Description	Char	Format	P	B	S	Legal values	Factory default	LCD
Source: emissivity / setpoint for alarm output	ES	X	*		*	1=constant number (E=0.950) E=external analogous input FTC1 D= E/XS digital selected FTC1-3	1	
Presel. emissivity value	EV	n.nnn	*		*	0.100 - 1.100		
Valley hold time(4)	F	nnn.n	*	*	*	0.000 - 998.9 s (999 = infinite)	000.0 s	V
Average time	G	nnn.n	*	*	*	000.0 – 999 s	000.0 s	A
Top of mA/mV range	H	nnn.n	*	*	*	(1)	(7)	H
Sensor / head ambient	I	nnn.n	*	*		in current scale (°C/°F)		
Switch panel lock	J	X	*		*	L=locked U=unlocked	unlocked	
Alarm output control	K	N	*		*	0=off 1=on 2=Target.; norm. open 3=norm. closed 4=Head; normal open 5=norm. closed 7=sensor / head ambient	?	
Bottom of mA/mV range	L	nnn.n	*	*	*	(1)	(8)	L
Output voltage	O	n.nnn	*		*	0.000 – 5.000 voltage in V 6=controlled by unit	6	
Output current	O	nn.nn	*		*	0.00 – 20.00 current in mA 21=over range 60=controlled by unit	60	L
Peak hold time (4)	P	nnn.n	*	*	*	000.0 998.9 s (999 = infinite)	000.0 s	P
Power	Q	nnnn	*	*				

Description	Char	Format	P	B	S	Legal values	Factory default	LCD
Presel. setpoint / relay function	SV	nnn.n				(1)		
Target temperature	T	nnn.n	*	*		in current scale (°C / °F)		
Temperature unit	U	X	*	*	*	C / F	C	U
Poll / Burst mode	V	X	*		*	P = poll B = burst	Poll mode	
Burst string contents	X$		*					
Multidrop address	XA	nnn	*		*	000 – 032 000 = single unit	000	
Bottom temperature of range	XB	nnn.n	*					
Restore factory defaults	XF				*			
Transmission	XG	n.nnn	*	*	*	0.100 - 1.000	1.000	T
High temperature of range	XH	nnn.n	*					
Sensor initialization	XI	n	*	*	*	1 after Reset, 0 if XI = 0		
Box temperature	XJ	nnn.n	*	*		in current scale(°C / °F)		
FTC 3 trigger / hold	XN	X	*		*	T = trigger H = hold	T	
Analog output mode	XO	n	*		*	0 = 0 – 20 mA 4 = 4 – 20 mA 5 = TCJ 6 = TCK 9 = mV	9	
Firmware revision	XR		*			e.g. 1.01		
Setpoint / relay function (10)	XS	nnn.n	*		*	(1)	250°C	
Trigger	XT	n	*	*		0 = inactive 1 = active	0	
Unit identification	XU		*			e.g. !XUMILT4		
Serial number	XV		*			e.g. 98123		
Advance hold hysterese (4)	XY	nnn.n	*		*			
Head calibration (9)	XZ		*		*			

(1) LT: -40 to 600°C (-40 to 1112°F)

(2) n = number, X = uppercase letter

(3) $ = UTQE
(4) setting average / peak / valley / advanced hold cancels all other hold modes
(6) LT: 23°C (73°F)
(7) LT: 500°C (932°F)
(8) LT: 0°C (32°F)
(9) XZ = 0123 4567 89AB CDEF set command checks format! Save values and restart firmware
(10) E0=1.100, E1=0.500, E2=0.600, E3=0.700, E4=0.800, E5=0.970, E6=1.000, E7=0.950
XS0=200, XS1=210, XS2=220, XS3=230, XS4=240, XS5=250, XS6=260, XS7=270
En / XSn set via command EP = n (n = 0 … 7)

Table 2: Command Set

12 Appendix

12.1 Determination of Emissivity

Emissivity is a measure of an object's ability to absorb and emit infrared energy. It can have a value between 0 and 1.0. For example a mirror has an emissivity of < 0.1, while the so-called "Blackbody" reaches an emissivity value of 1.0. If a higher than actual emissivity value is set, the output will read low, provided the target temperature is above its ambient temperature. For example, if you have set 0.95 and the actual emissivity is 0.9, the temperature reading will be lower than the true temperature.
An object's emissivity can be determined by one of the following methods:

1. Determine the actual temperature of the material using an RTD (PT100), a thermocouple, or any other suitable contact temperature method. Next, measure the object's temperature and adjust emissivity setting until the correct temperature value is reached. This is the correct emissivity for the measured material.

2. If possible, apply flat black paint to a portion of the surface of the object. The emissivity of the paint must be above 0.98. Next, measure the temperature of the painted area using an emissivity setting of 0.98. Finally, measure the temperature of an adjacent area on the object and adjust the emissivity until the same temperature is reached. This is the correct emissivity for the measured material.

12.2 Typical Emissivity Values

The following table provides a brief reference guide for determining emissivity and can be used when one of the above methods is not practical. Emissivity values shown in the table are only approximate, since several parameters may affect the emissivity of a material. These include the following:

1. Temperature
2. Angle of measurement
3. Geometry (plane, concave, convex)
4. Thickness
5. Surface quality (polished, rough, oxidized, sandblasted)
6. Spectral range of measurement
7. Transmission (e.g. thin films plastics)

To optimize surface temperature measurements, consider the following guidelines:

- Determine the object emissivity using the instrument which is also to be used for the measurements.
- Avoid reflections by shielding the object from surrounding temperature sources.
- For higher temperature objects use instruments with the shortest wavelength possible.
- For translucent materials such as plastic foils or glass, assure that the background is uniform and lower in temperature than the object.
- Mount instrument perpendicular to surface if possible. In all cases, do not exceed angles more than 30° from incidence.

METALS

Material	Emissivity		
	3.9 µm	5 µm	8 – 14 µm
Aluminum			
Unoxidized	0.02-0.2	0.02-0.2	0.02-0.1
Oxidized	0.2-0.4	0.2-0.4	0.2-0.4
Alloy A3003, Oxidized	0.4	0.4	0.3
Roughened	0.1-0.4	0.1-0.4	0.1-0.3
Polished	0.02-0.1	0.02-0.1	0.02-0.1
Brass			
Polished	0.01-0.05	0.01-0.05	0.01-0.05
Burnished	0.3	0.3	0.3
Oxidized	0.5	0.5	0.5
Chromium	0.03-0.3	0.03-0.3	0.02-0.2
Copper			
Polished	0.03	0.03	0.03
Roughened	0.05-0.15	0.05-0.15	0.05-0.1
Oxidized	0.5-0.8	0.5-0.8	0.4-0.8
Gold	0.01-0.1	0.01-0.1	0.01-0.1
Haynes			
Alloy	0.3-0.8	0.3-0.8	0.3-0.8
Inconel			
Oxidized	0.6-0.9	0.6-0.9	0.7-0.95
Sandblasted	0.3-0.6	0.3-0.6	0.3-0.6
Electropolished	0.15	0.15	0.15
Iron			
Oxidized	0.6-0.9	0.6-0.9	0.5-0.9
Unoxidized	0.05-0.25	0.05-0.25	0.05-0.2
Rusted	0.5-0.8	0.5-0.8	0.5-0.7
Molten	—	—	—
Iron, Cast			
Oxidized	0.65-0.95	0.65-0.95	0.6-0.95
Unoxidized	0.25	0.25	0.2
Molten	0.2-0.3	0.2-0.3	0.2-0.3
Iron, Wrought			
Dull	0.9	0.9	0.9
Lead			

Polished	0.05-0.2	0.05-0.2	0.05-0.1
Rough	0.4	0.4	0.4
Oxidized	0.2-0.7	0.2-0.7	0.2-0.6
Magnesium	0.03-0.15	0.03-0.15	0.02-0.1
Mercury	0.05-0.15	0.05-0.15	0.05-0.15
Molybdenum			
Oxidized	0.3-0.7	0.3-0.7	0.2-0.6
Unoxidized	0.1-0.15	0.1-0.15	0.1
Monel (Ni-Cu)	0.1-0.5	0.1-0.5	0.1-0.14
Nickel			
Oxidized	0.3-0.6	0.3-0.6	0.2-0.5
Electrolytic	0.1-0.15	0.1-0.15	0.05-0.15
Platinum			
Black	0.9	0.9	0.9
Silver	0.02	0.02	0.02
Steel			
Cold-Rolled	0.8-0.9	0.8-0.9	0.7-0.9
Ground Sheet	0.5-0.7	0.5-0.7	0.4-0.6
Polished Sheet	0.1	0.1	0.1
Molten	0.1-0.2	0.1-0.2	—
Oxidized	0.7-0.9	0.7-0.9	0.7-0.9
Stainless	0.15-0.8	0.15-0.8	0.1-0.8
Tin (Unoxidized)	0.05	0.05	0.05
Titanium			
Polished	0.1-0.3	0.1-0.3	0.05-0.2
Oxidized	0.5-0.7	0.5-0.7	0.5-0.6
Tungsten	0.05-0.5	0.05-0.5	0.03
Polished	0.05-0.25	0.05-0.25	0.03-0.1
Zinc			
Oxidized	0.1	0.1	0.1
Polished	0.03	0.03	0.02

Tab. 10: Typical Emissivity Values for Metals

	NON-METALS	
Material	Emissivity	
3.9 µm	5 µm	8 – 14 µm
Asbestos	0.9	0.95
Asphalt	0.95	0.95
Basalt	0.7	0.7
Carbon		
Unoxidized	0.8-0.9	0.8-0.9
Graphite	0.7-0.9	0.7-0.8
Carborundum	0.9	0.9
Ceramic	0.8-0.95	0.95
Clay	0.85-0.95	0.95
Concrete	0.9	0.95
Cloth	0.95	0.95
Glass		
Plate	0.98	0.85
"Gob"	0.9	—
Gravel	0.95	0.95
Gypsum	0.4-0.97	0.8-0.95
Ice	—	0.98
Limestone	0.4-0.98	0.98
Paint (non-al.)	—	0.9-0.95
Paper (any color)	0.95	0.95
Plastic, opaque at 500 µm (20 mils) thickness	0.95	0.95
Rubber	0.9	0.95
Sand	0.9	0.9
Snow	—	0.9
Soil	—	0.9-0.98
Water	—	0.93
Wood, Natural	0.9-0.95	0.9-0.95

Tab. 11: Typical Emissivity Values for Non-Metals

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